Reference Document 2.1.
NASA-GRC Test Tank and Test Facility

Test Tank

The test tank is designed to representative of the Altair Lunar Lander methane ascent tanks from a geometric and thermal performance standpoint. The 304 stainless steel spherical tank is four foot in diameter (outside) with a smooth outer mold line to accommodate installation of multilayer (MLI) insulation. The maximum design pressure is 350 psig [TBR], with a service temperature range of -320°F to 100°F. The tank filled with methane, including internals and insulation, weighs approximately 2,700 lbs [TBR]. The tank is ASME approved and stamped, and was designed and fabricated in accordance with the current edition of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and other sections as applicable.

Figure 1 is a CAD image of the bare tank in the existing SMiRF Test Tank Transport Cart (left) and integrated into the SMiRF vacuum chamber within the cryoshroud (right). Side mounting brackets at the tank midline interface with the existing ground fixture, and can be removed after facility installation to allow MLI coverage. Three 5/8-inch threaded support rod mounting bosses are positioned at in the top hemisphere of the tank for facility integration, and three more bosses in the bottom hemisphere for potential handling needs. The mounting bosses are recessed into the tank wall to maintain the smooth outer mold line of the tank.

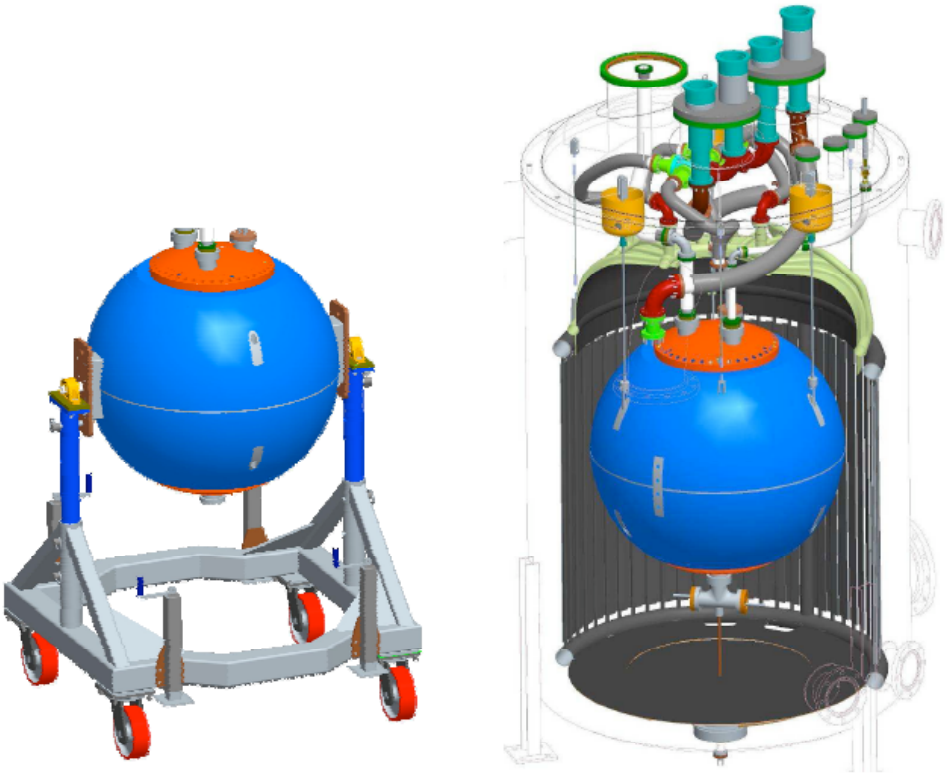


Figure 1: Test Tank in Ground Fixture (left) and SMiRF (right)

The tank lids are designed to allow interchangeable mounting at the top or bottom of the tank, and to provide human entry/access to the tank internal volume. The top lid has three 3-inch ports to accommodate a fill line, vent line (including instrumentation leads), and a gaseous helium line. The bottom lid has one 3-inch port for attaching a "T" section [TBR] for the bubbler bar line, drain line, pump wires conduit, and bottom load cell attachment.

Fig. 2. Test Tank.

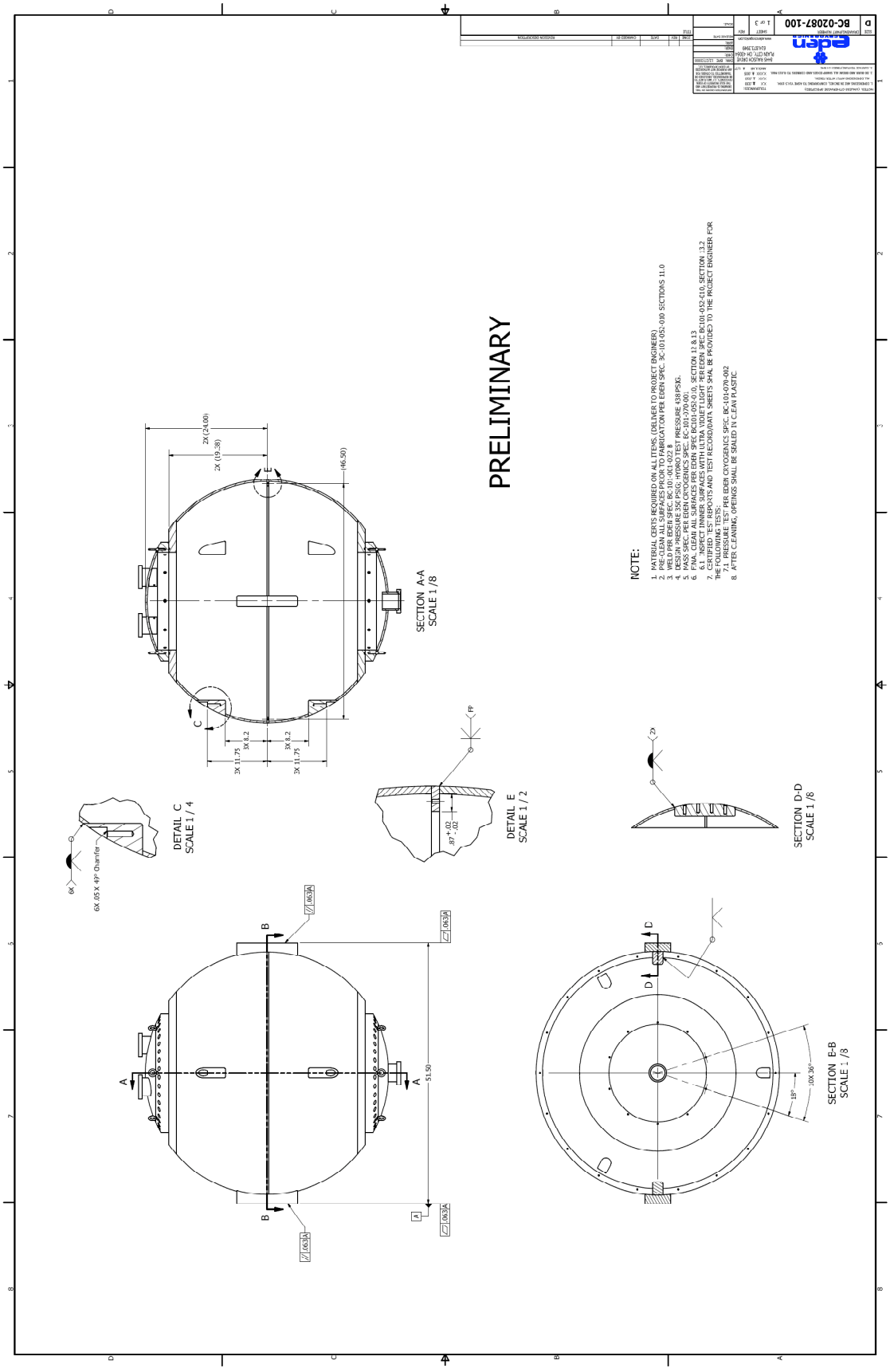


Fig. 3. Tank Top Lid.

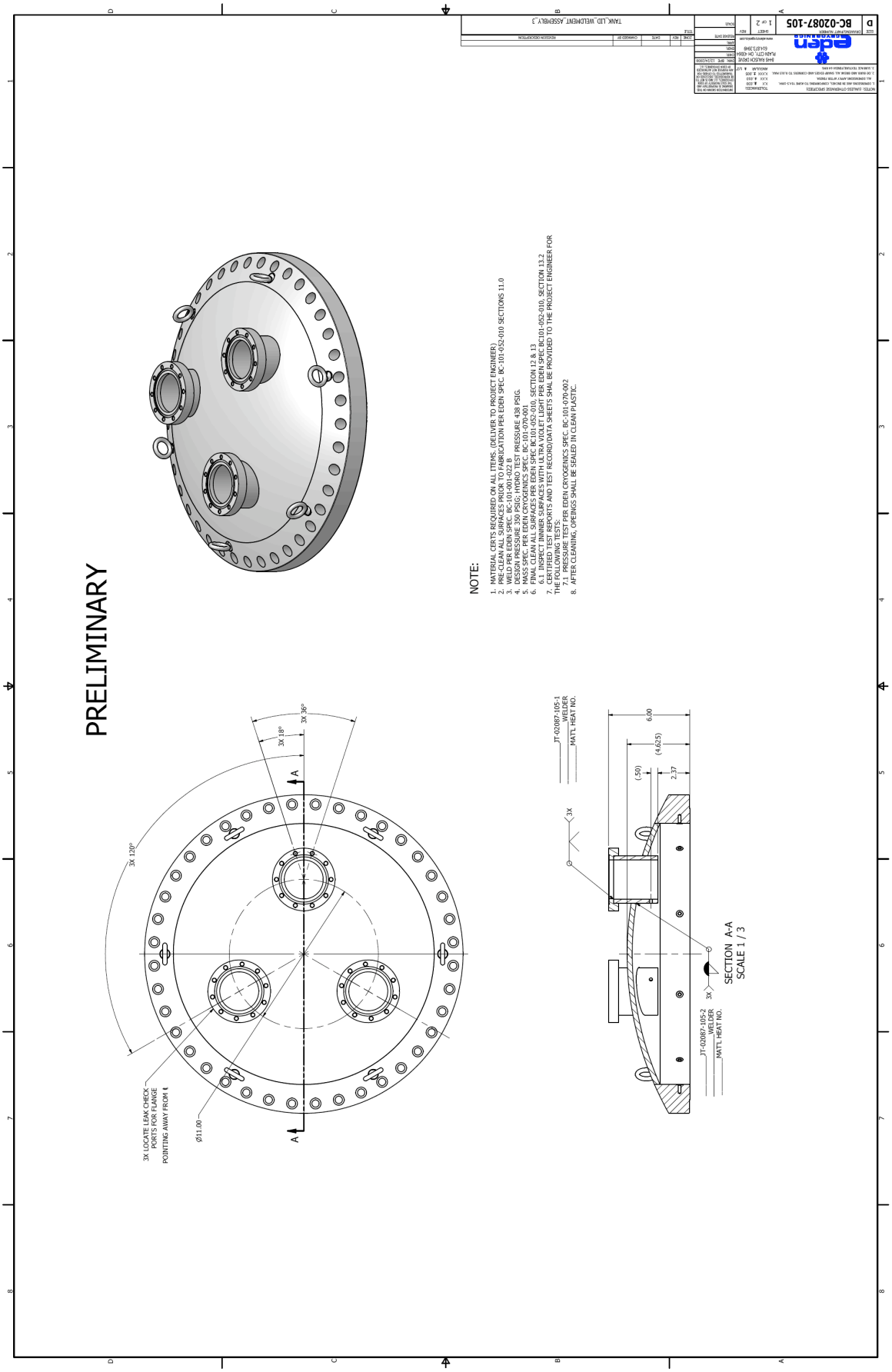


Fig. 4. Tank Bottom Lid.

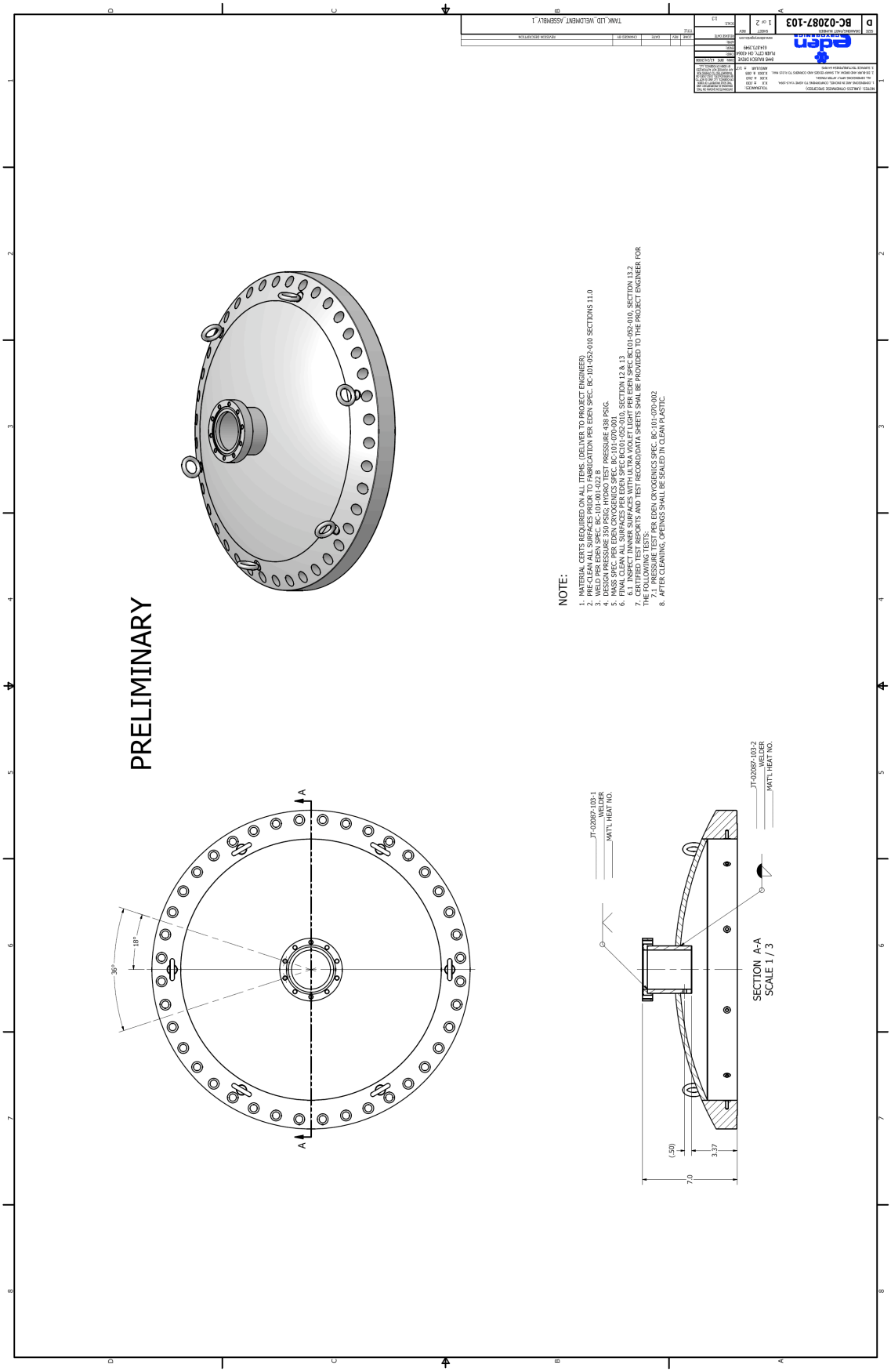


Fig. 5. Tank Removable Bracket.

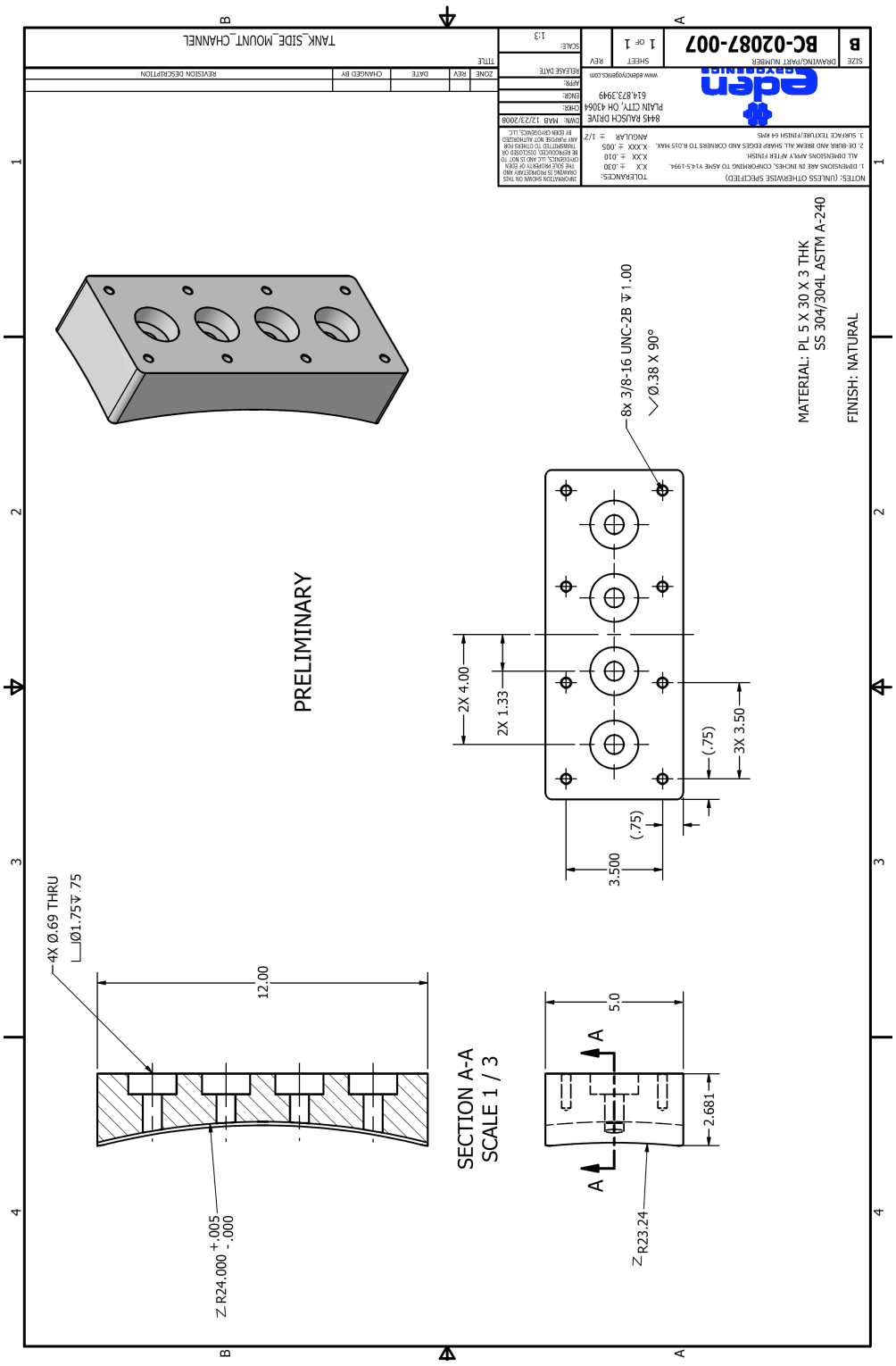


Fig. 6. Thermal Shroud Dimensions.

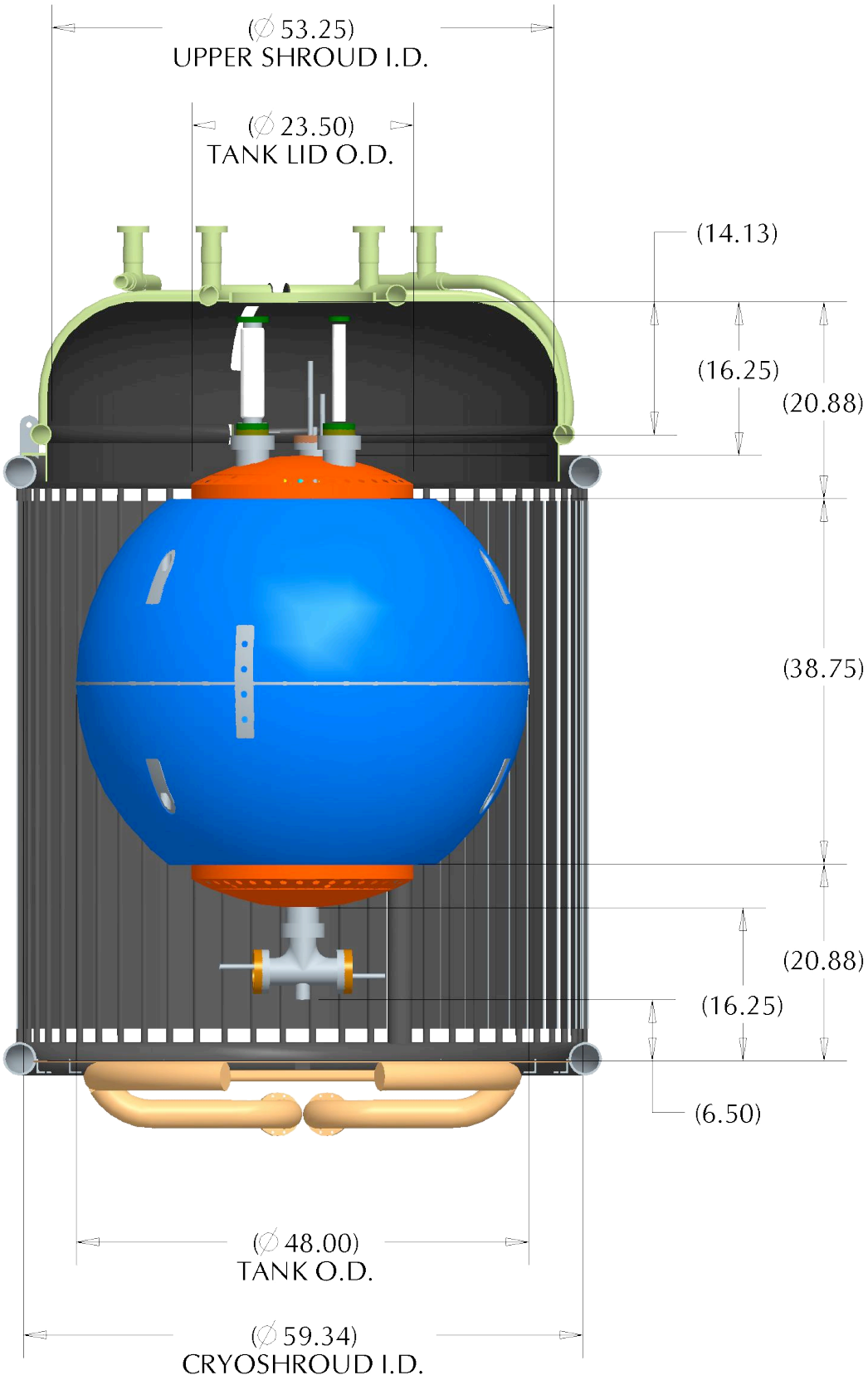
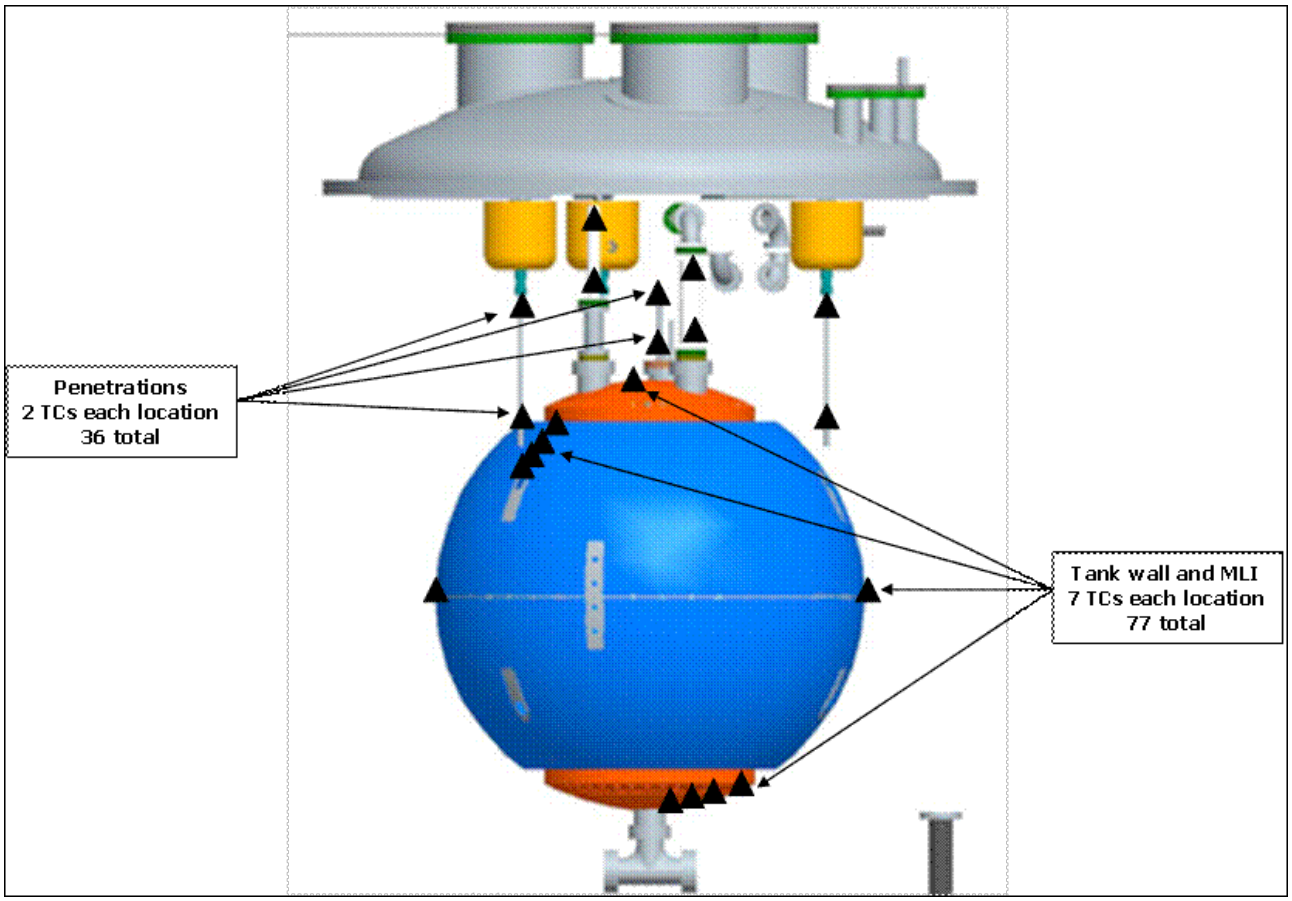


Fig. 7. Suggested Locations of the MLI Temperature Profile Measurements (77 thermocouples in this configuration. The vendor is not responsible for instrumenting the penetrations).



Tank Penetrations and Supports: Conduction Heat Leak

Solid conduction heat leak into the tank via penetrations has been estimated using thermal integral calculations and confirmed with a SINDA model of the test tank. Table I provides a breakdown of the various penetrations, thermal integral calculation assumptions, and associated heat leak results. The total estimated heat leak via penetrations is approximately 4 watts.

Table I. Penetrations Heat Leak (Thermal Integral Summary Results).

Penetration	Material	Crossect Area (m^2)	Length (m)	Hot Temp (K)	Cold Temp (K)	Unit Heat Leak (W)	Qty	Total Heat Leak (W)	%Total Heat Leak	Comments
Vent	Stainless Steel (304)	8.22E-04	1	300	135	1.788399	1	1.788	43%	3" sch 10S, from top nozzle #1
Sensor wires	OFHC Copper	1.27E-08	1	300	92	0.001098	40	0.044	1%	36 AWG, from top nozzle #1
Fill	Stainless Steel (304)	2.66E-04	1	300	135	0.579616	1	0.580	14%	1" sch 10S, from top nozzle #2
GHe	Stainless Steel (304)	5.45E-05	1	300	135	0.118614	1	0.119	3%	0.5" (0.049" wall), from top nozzle #3
Bubbler inlet	Stainless Steel (304)	5.45E-05	3	300	92	0.047485	1	0.047	1%	0.5" (0.049" wall), from bottom nozzle
Drain	Stainless Steel (304)	5.45E-05	3	300	92	0.047485	1	0.047	1%	0.5" (0.049" wall), from bottom nozzle
Mixer wires	OFHC Copper	2.01E-06	3	300	92	0.05808	3	0.174	4%	14 AWG, from bottom nozzle
Mixer conduit	Stainless Steel (304)	1.27E-04	3	300	92	0.110907	1	0.111	3%	0.5" sch 10S, from bottom nozzle
Support rods	Stainless Steel (304)	7.13E-05	0.4572	300	92	0.407194	3	1.222	30%	3/8" solid rod
								4.132	100%	

Figure 8 shows a bar and pie chart of the heat leak contribution for each of the penetrations. The highest heat leak is through the vent line. Heat leak through the support rods is the next largest contributor, although it's a conservatively high estimate since no thermal resistances are accounted for at the mounting interfaces. The fill line is the third largest penetration heat leak source. The penetrations are instrumented with thermocouples to provide data for calculating the actual heat leak during testing.

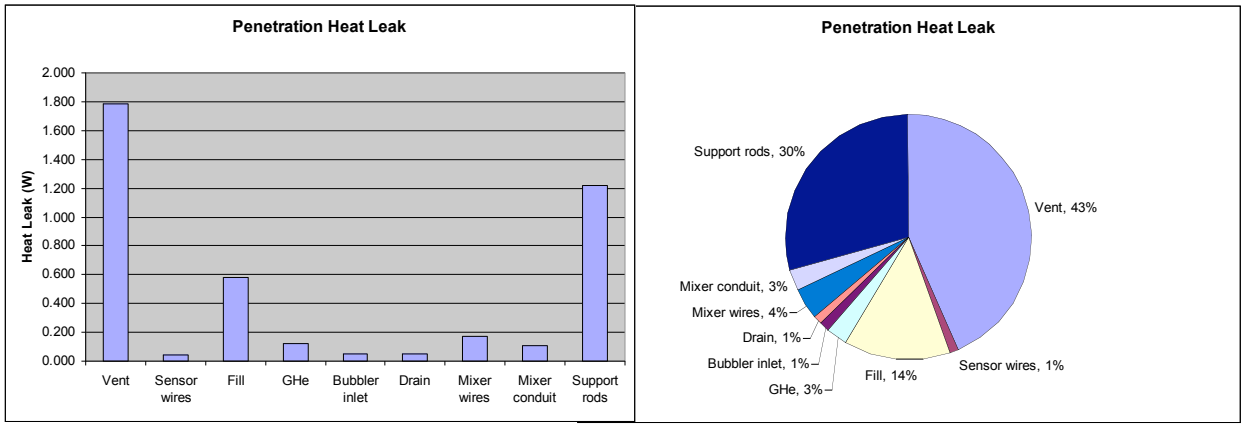
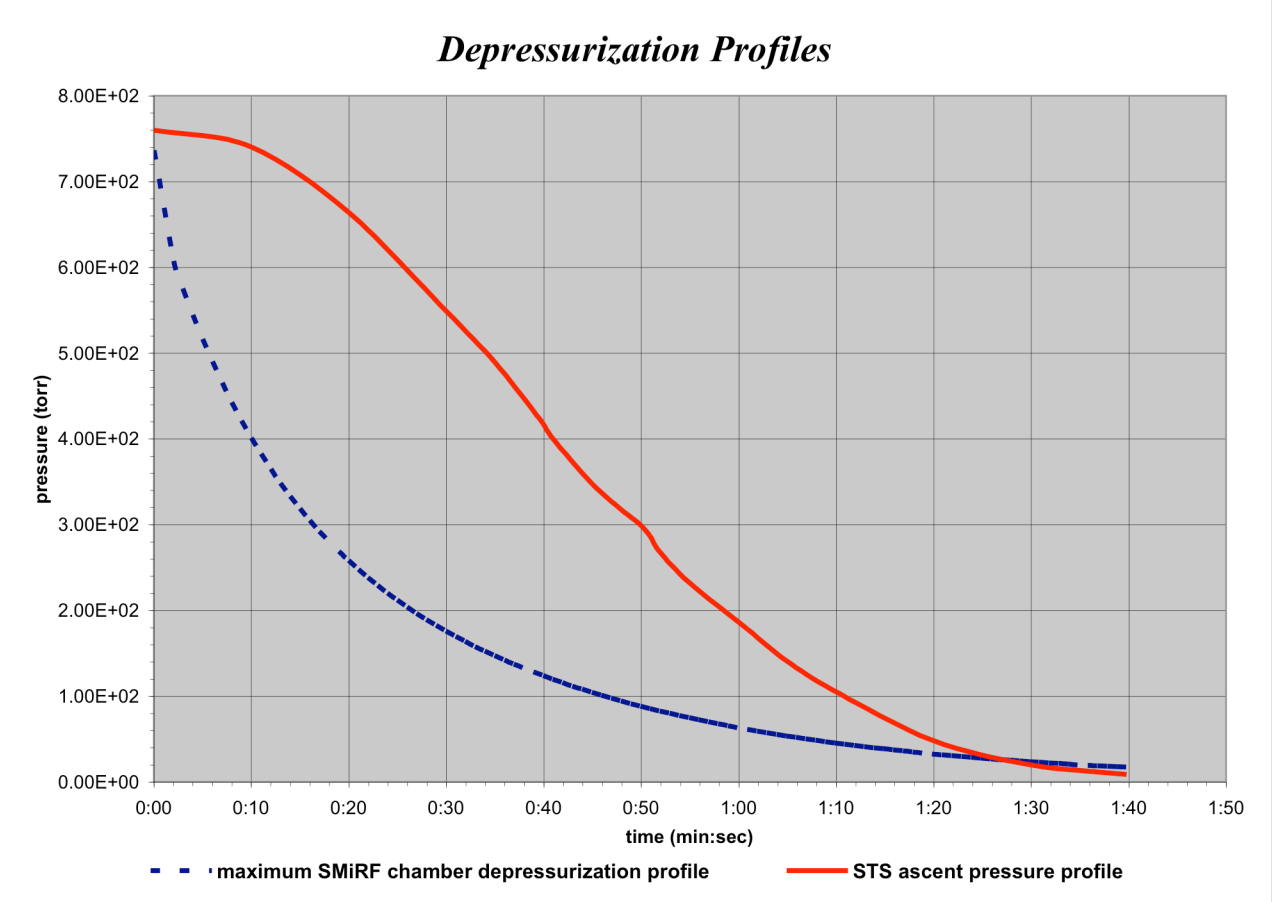


Fig. 8. Bar & Pie Charts of Penetration Heat Leak.

Fig. 9. Maximum Test Chamber Depressurization Profile.

(disregard the STS profile)